TWO NEW SPECIES OF FRESHWATER ATYID SHRIMPS (CRUSTACEA: DECAPODA: ATYIDAE) FROM NORTHERN QUEENSLAND AND THE DISTRIBUTIONAL ECOLOGY OF THE *CARIDINA TYPUS* SPECIES-GROUP IN AUSTRALIA

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Two new species of freshwater atyid shrimps are described from tropical Queensland and the four members of the *Caridina typus*-group now known from Australia are reviewed. *Caridina confusa* sp. nov. is a slender animal with a relatively long, dorsoventrally flattened, naked rostrum, found predominantly in open grassland streams of the Atherton Tableland. *Caridina spinula* sp. nov., distinguished by its spiniform pterygostomian angle, is found in small secondary rainforest streams on northeastern Cape York Peninsula. Although both these new species look superficially like *C. zebra* Short, 1993, they can be distinguished by a combination of characteristics such as rostrum length, shape of the pterygostomian angle, length-depth ratio of the sixth abdominal segment and the shape of the protopod of the uropod. *C. zebra* is found predominantly in primary rainforest streams of the Atherton Tableland and *C. typus* is found in coastal tropical streams. All species are allopatric, except for slight overlap in the distribution of *C. zebra* and *C. confusa* in some anthropogenically disturbed streams of the upper Barron and the upper North Johnstone catchments. □ *Crustacea, Atyidae, Caridina, Queensland, distribution.*

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Caridina zebra Short, 1993 is a tropical montane species belonging to the *Caridina typus* species-group (Short, 1993). This group is characterised by a short, dorsally unarmed rostrum, the presence of epipods on the 1st four pairs of pereiopods and the presence of an appendix interna on the endopod of the 1st pleopod of ♂♂. Short (1993) reported *C. zebra* from the montane streams of the wet tropical rainforest areas of the Tully, Herbert and Johnstone River catchments, at altitudes of 400-900m. A smaller population of *C. zebra*, is also known to occur in the lower Koolmoon Creek (alt. 150m), a tributary of the Tully River (Hughes *et al*, 1996). *Caridina typus* Milne Edwards, 1837 has been reported from coastal lowland streams at Cooktown and on Dunk Island (Roux, 1926; Riek, 1953; Short, 1993).

Re-examination of Short's material from the Wet Tropics-Atherton Tableland area (Short, 1993: 62) indicated the presence of two distinct morphological groups, one group possessing a longer rostrum, from anthropogenically disturbed grassland areas and the other possessing a shorter rostrum, generally from relatively undisturbed rainforest areas. This was confirmed by examination of recently collected material from the same area (17-18°S, 145-146°E). Although the distribution of these two groups tend to overlap slightly, they are morphologically and ecologically distinct. They each warrant species status. Since the short rostrum form is the holotype of *C. zebra* Short, 1993, its status is maintained. The long rostrum form is described as a new species, *Caridina confusa*.

A third morphological and geographically isolated group was recently collected from the streams in the McIlwraith Range, Cape York Peninsula (13°35-44'S, 143°20'E). This is also described as a new species, *Caridina spinula*.

MATERIAL AND METHODS

Specimens from the Queensland Museum are provided with catalogue numbers with the prefix QM. Unless otherwise stated all material was collected by the first author and various colleagues from Griffith University and the Queensland Department of Natural Resources (formerly part Department of Primary Industries). All examined specimens will be deposited in the Queensland Museum. Collection was made using a standard pond net and all samples immediately preserved. The abbreviations used are: 6S, sixth abdominal segment length; A1P, antennular pe-

dunele length; A2P, antennal peduncle length; CL, post-orbital carapace length; RL, rostrum length; SC, scaphocerite length; SL, body length from the post-orbital margin of the carapace to the tip of the telson; ST, stylocerite length; T, telson length.

The format of the description and morphological terms follow Choy (1991). Although problems in the terminology of cuticle spination and setation still exist, we have followed the terminology of Felgenhauer (1992).

SYSTEMATICS

Caridina typus Milne Edwards, 1837

Caridina typus Milne Edwards, 1837, p. 363, pl. 25*bis*, figs. 4, 5; Holthuis, 1965, p. 10, fig. 3.
Caridina typus typica Bouvier, 1925, p.250, figs. 272-295.
Caridina typa Roux, 1926, p. 201; Riek, 1953, p. 117.

MATERIAL EXAMINED. Proserpine River below Proserpine (20°24.2'S, 148°31.1'E), 19.10.94, L.K. Patterson, 15 ♂♂ (2.5-4.1mm CL), 7 ♀♀ (4.8-5.1mm CL); QM W4795, Brandy Creek near Proserpine (20°20'S, 148°38'E), 21.4.75, R. Monroe, P. Filewood, ovigerous ♀ (7.81mm CL), non-ovigerous ♀ (5.82mm CL); QM W14241, Lindeman Is., west side, small creek near golf course (20°27'S, 149°02'E), 27.3.83, J. Short, ♂♂ (4.03-4.09mm CL), ♀♀ (5.5-7.2mm CL).

DIAGNOSIS. Rostrum short, laterally compressed, with 1-5 teeth on ventral margin; diaeresis with more than 20 hamate setae; intermediate setae on posterior telsonic margin longer than lateral pair, plumose, with sclerotinous plug; egg small (length <0.52mm).

REMARKS. *Caridina typus* has a wide ranging distribution, extending from eastern and southern Africa through the Indian Ocean islands, Southeast Asia to Japan, Australia and through to French Polynesia. In Australia it has been collected only from the northeastern coastal areas of the mainland and from the nearby islands, between latitudes 15-21°S. Although it seems to be confined to the lower reaches of coastal and island Australian streams, *C. typus* has been collected from altitudes of 300m elsewhere (Choy, 1991).

Caridina zebra Short, 1993

Caridina zebra Short, 1993, p. 62 (in part).

MATERIAL EXAMINED. All specimens listed by Short, 1993, p. 62. ADDITIONAL MATERIAL. Upper Tully Catchment: QMW17118, Tully River above Koombooloomba Dam (17°49'S, 145°35'E, 720m), 23.10.91, numerous specimens; Koombooloomba Creek (17°51.5'S, 145°35.9'E, 790m), 30.10.93, 25 specimens; Echo Creek (17°59.5'S, 145°38.3'E, 830m), 30.10.93, 50 specimens; Carpentar Creek (17°53.3'S, 145°35.3'E, 750m), 30.10.93, 23 specimens; Costigan Creek (17°56'S, 145°37'E, 770m), 3.12.94, 11 specimens (1.8-4.2mm CL); QMW17119, Koolmoon Creek (17°44'S, 145°34'E), 25.7.90, 4 specimens; Koolmoon Creek at Walter's Waterhole (17°44.11'S, 145°34'E, 760m), 30.10.93, 7 specimens; Koolmoon Creek near Tully River confluence (17°44.9'S, 145°37.1'E, 150m), 31.10.93, 6 specimens. Upper Herbert Catchment: QMW17116, Blunder Creek (17°46'S, 145°33'E), 28.11.90, 3 specimens; Blunder Creek (17°47.5'S, 145°32.2'E, 750m), 3.12.94, 1 ♂, 2 ovigerous ♀♀ (4.08-5.6mm CL); Rocky Creek (17°44.7'S, 145°31.3'E, 760m), 30.10.93, 34 specimens; Cameroon Creek, 3.12.94, 14 specimens (1.4-4.2mm CL);millstream River at Diversion Weir (17°40'S, 145°26'E, 720m), 12.10.94; 2 specimens; Upper North Johnstone Catchment: QMW19261, Malanda Falls, (17°20.2'S, 145°43.8'E, 750m), 2.11.93, 30 specimens (including ovigerous ♀♀); QMW19285, Raspberry Creek, 3-4 km above Malanda Falls (17°22.75'S, 145E33.6'E), 14.11.91, J. Short, P. Davie, A. Humpherys, silt & para grass (*Urochloa mutica*) infested stream; Raspberry Creek (17°25.5'S, 145°28.8'E), 31.10.93, 100 specimens; North Johnstone River (17°40'S, 145°39'E, 650m), 5.8.93, 2 ♀♀, 1 ♂; Ithaca Creek (17°24'S, 145°38'E, 650m), 7.11.94, 2 ♀♀; Ithaca Creek at Bauld Rd (17°23'S, 145°38'E, 685m), 13.10.94, 50 specimens; Thiaki Creek at edge of rainforest (17°25'S, 145°32'E, 795m), 5.12.94, 9 specimens (3.4-4.8mm CL); Thiaki Creek in rainforest, 13.10.94, 15 specimens; North Beatrice River at Palmerston Highway (17°32'S, 145°36'E, 720m), 13.10.94, 25 specimens; Henrieta Creek at Palmerston Highway (17°36'S, 145°45'E, 360m), 14.10.94, 18 specimens; QMW18722, Goolagan Creek, 23.10.91, numerous specimens; Goolagan Creek (17°36.3'S, 145°45.5'E, 370m), 32 specimens; Upper Barron Catchment: QMW3078, Atherton tap water (17°16'S, 145°29'E), 14.5.62, QDPI, 2 ♂♂; Barron River at The Crater (19°17'S, 145°29'E), 7.12.94, 10 ♂♂, 8 ♀♀ (2 ovigerous) (2.0-5.0mm CL); Barron River at Hemmings Road, 28.11.94, 3 juveniles; Wright's Creek (17°04'S, 145°45'E), 4.12.94, 4 ♀♀ (1 ovigerous); Peterson Creek (17°17'S, 145°36'E), 1994-95, numerous specimens; Kauri Creek (16°54'S, 145°38'E), 1994-95, numerous specimens; Prior's Creek, 1 ♀; Upper Gwynne Creek in small pocket of rainforest (17°23.3'S, 145°30.3'E), 5.12.94, 2 ♀♀, 19 ♂♂ (3.6-4.0mm CL).

DIAGNOSIS. Body (Fig. 1b) rotund, may have black and white transverse banding; rostrum (Fig. 2a-f) short, extending to base of 3rd antennular peduncle (RL<0.5CL), dorsoventrally com-

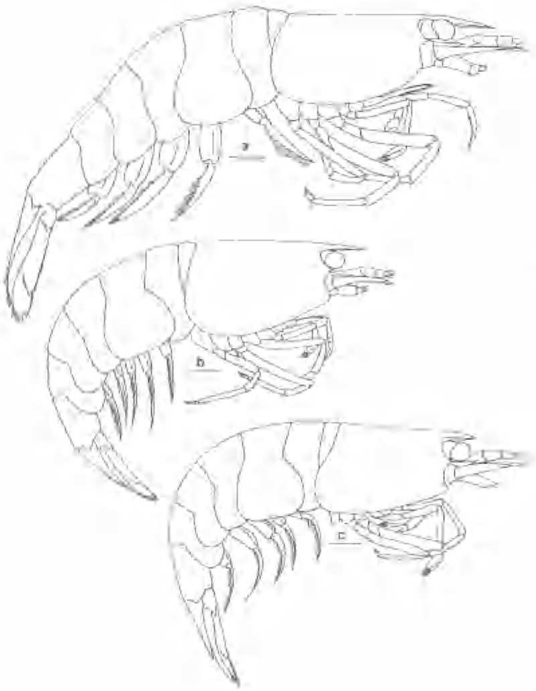

FIG. 1. a, *Caridina confusa* sp. nov., ♂; b, *C. zebra* Short 1993, ♂; c, *C. spinula* sp. nov., ♂. Scale = 1mm.

pressed, may have an apical tooth (Fig. 2e); pterygostomian angle acute but not spiniform; dorsal telsonic spines (Fig. 3a) on posterior 0.66 of telson; posterior telsonic margin (Fig. 3f, g) usually with median spine, sub-lateral pair of setae sigmoid, longer than intermediate setae, setation numerically variable; protopod of uropod (Fig. 3a, d) elongate, spinate; eggs large (length <1.32mm); found mainly in primary rainforest streams on the Atherton Tableland along the Lamb-Francis-Cardwell Ranges.

REMARKS. Specimens of *C. zebra* from some locations (streams in the upper Barron Catchment) may seem to have a fairly long rostrum (Fig. 2a, d, f), thus resembling *C. confusa* sp. nov. However, the rostrum length relative to the carapace length as well as other features (Table 2), such as the relative lengths of the antennular peduncle, scaphocerite, sixth abdominal segment and the telson are characteristic of this species. *Caridina zebra* is one of only two species of atyid shrimps in the primary rainforest streams of the upper Tully (the other being *Australatya striolata*), where it is very abundant. In other catchments (Barron, N. Johnstone and Herbert), it is found mainly in the rainforest reaches of streams. However, it may be common in some disturbed streams such as Raspberry, Ithaca and Prior's Creeks. Unlike the upper Tully, which has an extensive relatively undisturbed forested area, the upper reaches of the Barron and N. Johnstone Rivers have been generally cleared and converted to pasture. Streams running through these open grassland are inhabited predominantly by *C. confusa* sp. nov. Only a small area of the upper Herbert catchment is in the wet (simple notophyll vine to complex mesophyll vine) forest; the rest is in dry sclerophyll forest. The abundance of *C. zebra* in these dry-zone streams is low; these streams are inhabited by another atyid, *Paratya australiensis*. It is interesting to note that only specimens from some of the rainforest streams of the upper Tully have the black and white transverse banding on their bodies (see Short, 1993). In all other areas these animals are translucent brown, with scattered tiny reddish and bluish-green chromatophores, similar to individuals of the two new species.

Caridina confusa sp. nov.

Caridina zebra Short, 1993, p. 62 (in part): QMW18841, QMW18720.

MATERIAL EXAMINED. HOLOTYPE. QMW-21906 ovigerous ♀, 4.8mm CL, 2.56mm RL, 19.2mm SL, Thiaki Creek at Seamark Road crossing (17°23.5'S, 145°32.5'E, 750m), stream flowing through open grazing land, fringing para grass, water depth 0.3-0.5m, velocity 0.3ms^{-1}, silty substrate, hand-netted amongst edge para grass, 26.8.94, S. Choy, M. Hopper. ALLOTYPE. QMW21907 adult ♂, 3.4mm CL, 2.0mm RL, 14.2mm SL, same locality data as holotype. PARATYPES. Upper North Johnstone Catchment: QMW21908 upper North Johnstone River near Bromfield Swamp (17°22.5'S, 145°31.3'E, 700m), open grazing land, fringing para grass, water depth 0.3-0.5m, hand-netted, 4.12.94, 21 ♂♂, 50 ♀♀ (13 ovigerous), (2.6-5.0mm CL); QMW18841, Thiaki Creek (17°24.9'S, 145°35.3'E, 750m), water depth 0.2m, electro-fished, 1992, Queensland DPI Fisheries Johnstone Rivers Survey, 1 ♂ (4.5mm CL); QMW18720, small creek about 6 km SW of Malanda (17°22.7'S, 145°33.6'E, 750m), fringing para grass, water depth 0.2-1.5m, electro-fished, 1992, Queensland DPI Fisheries Johnstone Rivers Survey, ♂ (3.9mm CL), 2 ♀♀ (4.3, 4.5mm CL); QMW18725, Thiaki Creek, macrophyte area, same data as QMW18841, 13 ♂♂ (3.2-4.8mm CL), 16 ♀♀ (3.8-6.1mm CL); QMW21909 Thiaki Creek at Seamark Road crossing (17°23.5'S, 145°32.5'E, 750m), open grazing land, fringing para grass, water depth 0.3-0.5m, hand-netted, 26.8.94, c. 100 specimens; QMW21910 Thiaki Creek at downstream edge of rainforest, fring-

ing para grass, depth 0.3-0.5m, hand-netted, 5.12.94, c. 50 spec.; QMW21917 Ithaca Creek in rainforest pocket (17°24.7'S, 145°30.3'E), leaf litter, water depth 0.3-0.5m, hand-netted, 5.12.94, 6 ♂♂, 7 ♀♀(2 ovigerous). Upper Barron Catchment: QMW21911 Gwynne Creek at Gillies Road crossing (17°20.3'S, 145°31.1'E, 750m), open grazing land with small pocket of riparian rainforest upstream, fringing para grass, water depth 0.3-0.6m, hand-netted, 5.12.94, c. 200 specimens (1.28-5.84mm CL); QMW21912 upper Gwynne Creek in rainforest pocket (17°23.3'S, 145°30.3'E, 720m), hand-netted, leaf litter, water depth 0.2-0.4m, 5.12.94, 14 specimens (4.0-5.4mm CL).

DIAGNOSIS. Body slender; rostrum long, reaching tip of antennular peduncle (RL >0.5CL), dorso-ventrally compressed, may be armed with one dorsal tooth; antennular peduncle long (A1P>0.5CL), antennal peduncle long (A2P>0.6CL), stylocerite long (ST>0.4CL), scaphocerite long (SC>0.8CL), sixth abdominal segment long (6S>0.5CL) with acute postero-ventral margin; telson long and slender (T>0.6CL); dorsal telsonic spines confined to posterior half of telson, median spine on posterior telsonic margin absent; protopod of uropods acute but not spinose.

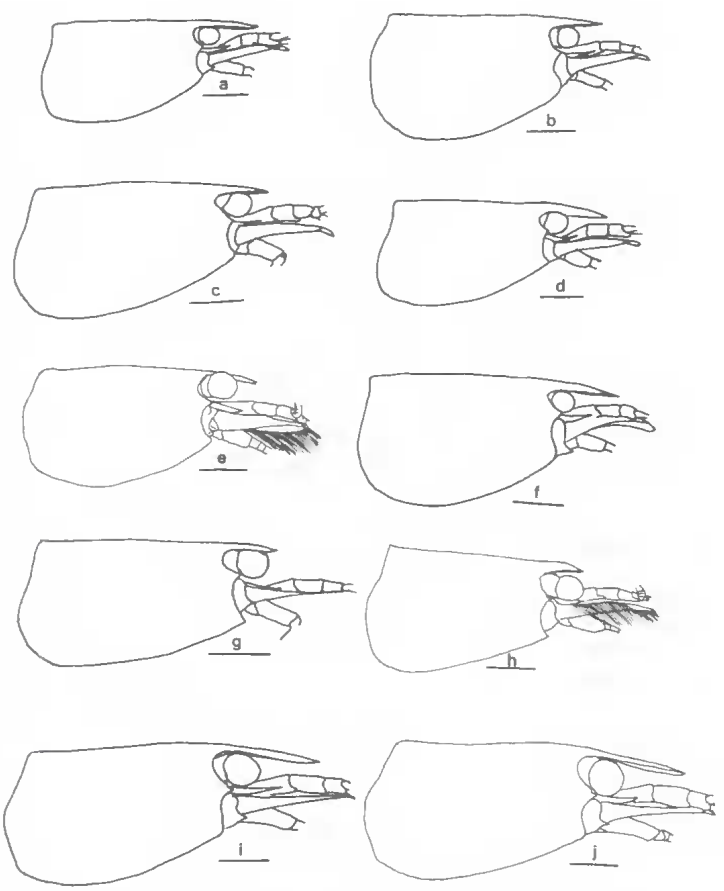

FIG. 2. a, *C. zebra*, from Wright's Ck, ovig. ♀; b, *C. zebra*, from Kauri Ck, ovig. ♀; c, *C. zebra*, from upper Gwynne Ck, ♀; d, *C. zebra*, from Peterson Ck, ♂; e, *C. zebra*, from upper Tully River, ♀; f, *C. zebra*, from upper Gwynne Ck, ♀; g, *C. spinula*, ♀; h, *C. spinula*, ♂; i, *C. confusa*, from Gywnne Ck, ovig. ♀; j, *C. confusa*, from Gwynne Ck, ♂. Scale = 1mm.

DESCRIPTION. Body (Fig. 1a) small, subcylindrical; ♂♂ in collection up to 4.9mm CL, ♀♀ up to 6.2mm CL.

Cephalothorax (Figs. 2i, j; 4a, b) rotund, glabrous, breadth c. 0.7 CL, depth c. 0.7 CL; rostrum long, 0.43-0.76 CL, length 12-16 X height, curving downward or sigmoid, reaching base to tip of distal segment of antennular peduncle, asctose, dorsoventrally compressed, a dorsal tooth may be present. Antennal spine short, strong, placed on lower orbital angle; pterygostomian angle obtuse, pterygostomian spine absent. Eyes large, c. 0.25 CL, corneal diameter c. equals eyestalk length, retinal pigmentation present. Antennular peduncle shorter than scaphocerite, 0.6-0.7 CL; stylocerite length 0.7 X proximal antennular segment length; anterolateral angle of proximal segment acute, reaching to about 0.15 X intermediate segment length; intermediate segment 0.7 X proximal segment length, about 1.7 X distal segment length; all segments with submarginal plumose setae; distal segment fringed laterally and apically with plumose setae. Antennal peduncle 0.5-0.6 X scaphocerite length; scaphocerite slightly longer than antennular peduncle, 0.8-1.0 CL, outer margin straight to slightly concave, asetose, ending in strong subapical spine, length 3.5 X width, distal lamella and inner margin with plumose setae. Branchial formula typical for genus.

Mandibles dimorphic, without palp; right mandible with 6-8 strong, sharp incisor teeth laterally;

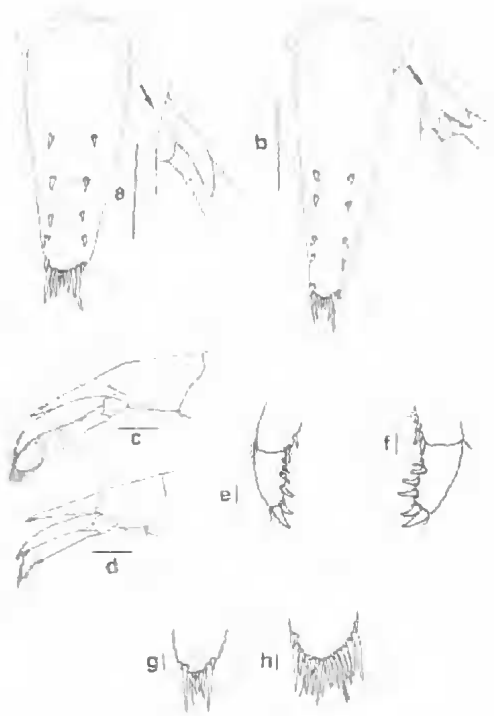

FIG. 3. a, *C. zebra*, telson and protopod of uropod, ♂, 4.8mm CL; b, *C. confusa*, telson and protopod, ♂, 4.32mm CL; c, *C. confusa*, posterior body; d, *C. zebra*, posterior body; e, *C. zebra*, dactylus of 3rd pereiopod of ♀; f, *C. zebra*, dactylus of 3rd pereiopod of ♂; g, h, *C. zebra*, posterior margin of telson. Scales = 1mm (a-d), 0.1mm (e-h).

medially two groups of setae, one group with bent hamate setae, other group with finer straight plumose setae; molar process ridged; left mandible with 6-8 strong teeth; medially three groups of setae, molar process ridged.

Maxillula with simple palp, slightly expanded distally, with long plumose setae distally, few simple setae proximally; lower lacinia with broadly rounded margin, bearing several rows of plumose and simple setae; upper lacinia broadly elongate, inner edge straight, with several rows of strong spiniform, hamate, denticulate and plumose setae, outer and lower inner margins with plumose setae.

Maxilla with slender tapering palp, shorter than upper endite cleft, setose; margin and submargin of upper and middle endite with simple, hamate, plumose and denticulate setae; lower endite with hamate setae; scaphognathite with regular row of long plumose setae on distal margin, with shorter hamate ones continuing down proximal triangular process which has c. 11 long simple setae, some with prominent dilation at base.

First maxilliped with broadly triangular lamellar palp, ending in pointed tip, margins with plumose setae; ultimate and penultimate segments of endites indistinctly divided; inner margin of ultimate segment with long denticulate setae, long rows of plumose, simple and hamate setae submarginally, transverse rows of plumose setae proximally; exopod flagellum distinct, well-developed, with submarginal and marginal plumose setae; caridean lobe narrow, with marginal and submarginal plumose setae.

Second maxilliped with dactylar and propodal segments of endopod fused; inner margins of all three proximal segments with long simple, hamate and plumose setae; exopod long, narrow with marginal long plumose setae distally and shorter ones proximally.

Third maxilliped reaching beyond tip of antennular peduncle; endopod three-segmented, basal segment length c. 7 X width; penultimate segment length c. 7 X width, c. 0.9 X basal segment length, with transverse rows of spiniform hamate setae; distal segment c. 0.9 X as long as penultimate segment, ending in large claw-like apical hamate seta surrounded by simple and plumose ones, behind which there are 7-9 hamate setae on distal 3rd of posterior margin, clump of serrate and pappose setae proximally; exopod reaching about 0.5 of 2nd endopod segment, distal margin with long plumose setae.

First pereiopod (Fig. 4c) reaching tip of basal antennular segment; chela length 1.7-2.2 X width, movable finger 1.1 X as long as palm, length 2.9-3.1 X width; finger tips rounded, without hooks, setal brushes well developed. Carpus attached to chela ventrally, excavated distodorsally, length 1.3-1.6 X width, 0.6-0.8 X chela length, 0.94 X merus length. Merus compressed, 0.6 X as wide as carpus. Ischium length 0.41 X merus length. Epipod present.

Second pereiopod (Fig. 4d) reaching tip of 2nd segment of antennular peduncle, more slender and longer than 1st pereiopod. Chela length 2..4-2.6 X width; movable finger length 4.9-5.1 X width, 1.5 X as long as palm; finger tips without hooks, setal brushes well developed. Carpus subconical, length 3.5-4.8 X width, 1.0-1.3 X chela length, 1.2 X merus length. Ischium length 0.67 X merus length. Epipod present.

Third pereiopod over-reaching antennular peduncle tip by about 0.33 distal propodus. Dactylus sexually dimorphic in adults (cf. Figs. 3e and 3f), length c. 3.8 X width, c. 0.2 X propodus

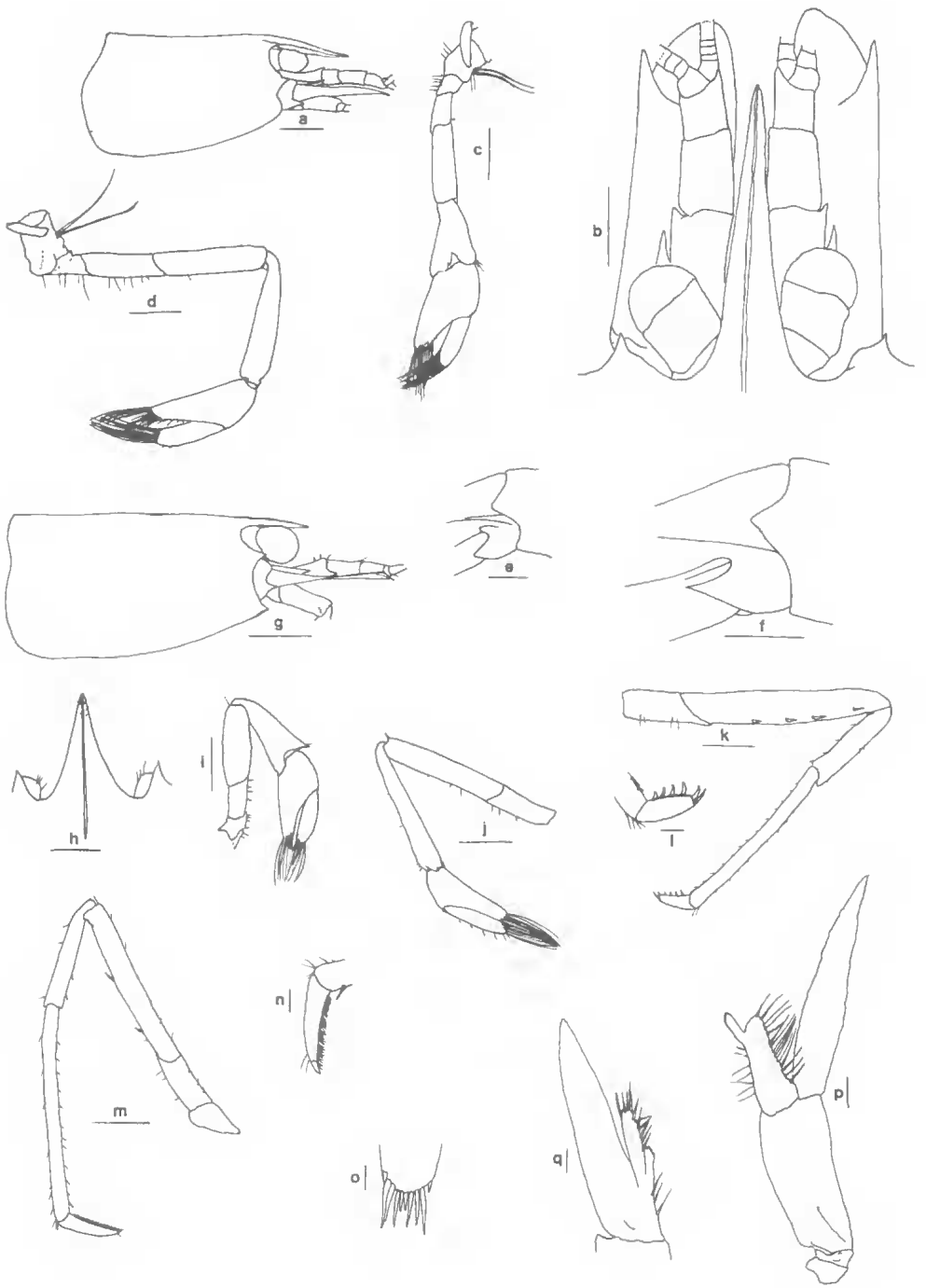

FIG. 4. a-e, *Caridina confusa* sp. nov.; a, cephalothorax; b, anterior cephalothorax, dorsal view; c, 1st pereiopod; d, 2nd pereiopod; e, margin of abdomen and telson, lateral view; f-q, *C. spinula* sp. nov.; f, margin of abdomen and telson, lateral view; g, cephalothorax; h, rostrum and orbital margin, dorsal view; i, 1st pereiopod; j, 2nd pereiopod; k, 3rd pereiopod; l, daetylus of 3rd pereiopod; m, 5th pereiopod; n, daetylus of 5th pereiopod; o, posterior margin of telson; p, 1st pleopod of adult ♂; q, endopod of 2nd pleopod of adult ♂. Scales = 1mm (a, g), 0.5mm (b-f, h-k, m), 0.1mm (l, n, o-q).

length, ending in prominent claw-like hamate seta surrounded by simple setae, behind which posterior margin bears 4-6 shorter spiniform hamate setae, these being more robust and upright in adult ♂♂. Propodus length 9-11 X width, posterior margin and lateral surface bearing two rows of small spiniform hamate setae. Carpus length 0.8 X propodus length, distal projection feebly developed, posterior and lateral surfaces with up to 10 small hamate setae, more spiniform setation in adult ♂♂. Merus 1.1-1.4 X length of carpus, with 2-3 strong, movable spiniform hamate setae along posterior margin. Ischium 0.2 X length of merus. Epipod present.

Fourth pereiopod reaching tip of 2nd segment to tip of 3rd segment of antennular peduncle, morphologically similar to 3rd pereiopod.

Fifth pereiopod reaching tip of 2nd segment to tip of 3rd segment of antennular peduncle. Dactylus unguiculate, compressed, length c. 3.8 X width, ending in claw-like apical hamate seta, bearing comb-like row of 55-65 hamate setae gradually increasing in length distally on posterior margin. Propodus length 8-10 X width, 3.6 X dactylus length, bearing two rows of 15-20 short hamate setae on posterior margin. Carpus length 0.5-0.6 X propodus length, bearing 2-7 short hamate setae, distal projection well-developed. Merus distinctly shorter (0.6-0.8 X) but broader (1.8 X) than propodus, bearing 2-4 large spiniform hamate setae. Ischium c. 0.4X length of merus, with simple setae. Epipod absent.

Abdomen (1a) well developed, rotund, glabrous, c. 2.8 X CL; sixth abdominal segment elongate, c. 0.6 X CL, length-depth ratio c.1.7; protopod of uropod (Figs. 3c, 2e) acute, aspinose; telson (Fig. 3b) narrow, length c. 0.7 X CL, dorsal spination (3-5 pairs) confined to posterior half of telson; posterior telsonic margin rounded, 3-4 pairs of spine-like setae, decreasing in size interiorly, median spine absent; diaeresis on telsonic exopod 10-16.

First ♂ pleopodal endopod with well developed appendix interna arising sub-distally. Appendix interna of 2nd ♂ pleopodal endopod reaching beyond middle of appendix masculina, with many retinaculae distally. Appendix masculina subcylindrical, long hamate setae distally and on inner lateral margin.

Live colour, translucent brown.

ETYMOLOGY. The specific epithet is chosen to highlight the fact that this new species can be confused with *Caridina zebra*.

REMARKS. *Caridina confusa* sp. nov. possesses a longer rostrum and is a much more slender and elongate animal than *C. zebra*. It is found primarily in open grassland streams, flowing through pastural land of the upper Barron (Gwynne Creek) and the upper North Johnstone (Ithaca and Thiaki Creeks) catchments. Smaller numbers are found, together with *C. zebra*, in the small, remnant rainforest areas of these streams. Despite extensive sampling, *C. confusa* sp. nov. has not been found anywhere else.

Caridina spinula sp. nov.

MATERIAL EXAMINED. HOLOTYPE. QMW-21913 adult ♀, 4.6mm CL, 1.2mm RL, 17.6mm SL, east-flowing first order tributary of Leo Creek, near crossing of Leo Creek Mine Road (13°44.6'S, 143°21.5'E), Nesbit River catchment, McIlwraith Range, Cape York, alt. c. 450m, 12.7.95, J. Marshall, N. Phillips. ALLOTYPE. QMW21914 adult ♂, 3.2mmCL, 0.8mm RL, 12.4mm SL, same locality data as holotype. PARATYPES. QMW21915 5 ♂♂, 7 ♀♀ (2 ovigerous), same data as holotype; QMW21922, west-flowing headwaters of Peach Creek (143°20'E, 13°44'S), Archer River catchment, McIlwraith Range, Cape York Peninsula, alt. c. 500m, 15.11.94, K. McDonald, 7 ♂♂ (3.8-4.6mm CL), 34 ♀♀ (1 ovig.) (2.6-5.4mm CL, ovig. ♀ 4.9mm).

DIAGNOSIS. Body rotund, rostrum short (RL <0.4CL), dorsoventrally compressed but slightly elevated towards dorsal carina, may have a tooth on the ventral margin, reaching to tip of basal antennular segment; pterygostomian angle broadly angular to acute and spiniform; dorsal telsonic spines confined to posterior half of telson, posterior median spine may be present; eggs large (length >1.32mm).

DESCRIPTION. Body (Fig. 1c) small, subcylindrical; ♂♂ in collection up to 2.7mm CL, ♀♀ up to 5.4mm CL.

Cephalothorax (Figs. 1c; 2g, h; 4g, h) rotund, glabrous, breadth c. 0.8 CL, depth 0.6-0.8 CL; rostrum short 0.20-0.33 CL, length 5-10 X height, curving downward, may be elevated medially, reaching tip of basal segment of antennular peduncle, may be setose dorsodistally, dorsoventrally compressed, a rostral tooth may be present on the ventral margin. Antennal spine short, placed on orbital angle; pterygostomian angle broadly angular (in Peach Creek specimens) or acute, spiniform (in Leo Creek specimens). Eyes large, c. 0.2 CL, corneal diameter c. equal eyestalk length, retinal pigmentation present. Antennular peduncle shorter than scaphocerite, 0.6-0.7 CL; stylocerite length 0.7 X proximal

antennular segment length; anterolateral angle of proximal antennular segment acute, reaching to about 0.15 X intermediate segment length; intermediate segment 0.7 X proximal segment length, about 1.7 X distal segment length; all segments with submarginal plumose setae; distal segment fringed laterally and apically with plumose setae. Antennal peduncle 0.5-0.6 X scaphocerite length; scaphocerite slightly longer than antennular peduncle, 0.6-0.7 CL, outer margin straight to slightly concave, asetose, ending in strong subapical spine, length 2.9-3.0 X width, distal lamella and inner margin with plumose setae. Branchial formula typical for genus.

Mandibles dimorphic, without palp; right mandible with 5-6 strong, sharp incisor teeth laterally; medially two groups of setae, one group with bent hamate setae, other group with finer straight plumose setae; molar process ridged; left mandible with 5-6 strong teeth; medially three groups of setae, molar process ridged.

Maxillula with simple palp, slightly expanded distally, with long plumose setae distally, few simple setae proximally; lower lacinia with broadly rounded margin, bearing several rows of plumose and simple setae; upper lacinia broadly elongate, inner edge straight, with several rows of strong spiniform, hamate, denticulate and plumose setae, outer and lower inner margins with plumose setae.

Maxilla with slender tapering palp, shorter than upper endite cleft, setose; margin and submargin of upper and middle endite with simple, hamate, plumose and denticulate setae; lower endite with hamate setae; scaphognathite with regular row of long plumose setae on distal margin, with shorter hamate ones continuing down proximal triangular process which has c. 11 long simple setae, some with prominent dilation at base.

First maxilliped with broadly triangular lamellar palp, ending in pointed tip, margins with plumose setae; ultimate and penultimate segments of endites indistinctly divided; inner margin of ultimate segment with long denticulate setae, long rows of plumose, simple and hamate setae submarginally, transverse rows of plumose setae proximally; exopod flagellum distinct, well-developed, with submarginal and marginal plumose setae; caridean lobe narrow, with marginal and submarginal plumose setae.

Second maxilliped with dactylar and propodal segments of endopod fused; inner margins of all three proximal segments with long simple hamate and plumose setae; exopod long, narrow with marginal long plumose setae distally and shorter ones proximally.

Third maxilliped reaching beyond tip of antennular peduncle; endopod three-segmented, basal segment length c. 6.5 X width; penultimate segment length c. 8 X width, c. 0.9 X basal segment length, with transverse rows of spiniform hamate setae; distal segment c. 0.9 X as long as penultimate segment, ending in large claw-like apical hamate seta surrounded by simple and plumose ones, behind which there are 7-9 hamate setae on distal third of posterior margin, clump of serrate and pappose setae proximally; exopod reaching about 0.5 of 2nd endopod segment, distal margin with long plumose setae.

First pereiopod (Fig. 4i) reaching tip of basal antennular segment; chela length 1.9-2.2 X width, movable finger 1.1 X as long as palm, length 2.0-3.4 X width; finger tips rounded, without hooks, setal brushes well-developed. Carpus attached to chela ventrally, excavated distodorsally, length 1.6-2.5 X width, 0.7-1.0 X chela length, 1.0 X merus length. Merus compressed,

TABLE 1. Morphometric ratios (range) of pereiopods of *Caridina zebra* Short, 1993, *C. confusa* sp. nov. and *C. spinula* sp. nov. D, dactylus; P, propodus; C, carpus; M, merus; L, length; W, width. 1, 2, 3 and 5 refer to the corresponding pereiopods.

Attribute	*C. zebra*	*C. confusa*	*C. spinula*
D1L/D1W	3.0-3.4	2.9-3.1	2.0-3.4
P1L/P1W	2.0-2.5	1.7-2.2	2.0-2.2
C1L/C1W	1.6-2.2	1.3-1.6	1.6-2.5
M1L/M1W	2.8-3.2	2.0-2.3	2.6-2.9
D1L/P1L	0.5-0.6	0.5-0.6	0.4-0.6
C1L/P1L	0.7-0.9	0.6-0.8	0.7-1.0
M1L/P1L	0.8-1.0	0.6-0.7	0.8-0.9
D2L/D2W	4.6-4.8	4.9-5.1	3.2-4.5
P2L/P2W	2.7-3.3	2.4-2.6	2.4-2.9
C2L/C2W	4.5-6.0	3.5-4.8	5.8-6.1
M2L/M2W	5.1-5.3	4.0-4.3	4.8-5.4
D2L/P2L	0.6-0.8	0.6-0.7	0.5-0.7
C2L/P2L	0.9-1.4	1.0-1.3	1.4-1.6
M2L/P2L	1.1-1.3	1.0-1.1	1.2-1.3
P3L/P3W	7.0-10.0	9.0-10.0	10.5-13.0
C3L/C3W	4.6-4.8	4.9-5.1	4.9-5.8
M3L/M3W	4.8-5.0	5.0-5.2	5.5-6.4
C3L/P3L	0.6-0.9	0.8-1.1	0.6-0.8
M3L/P3L	1.1-1.3	1.1-1.4	1.1-1.3
P5L/P5W	11.5-14.5	8.0-11.0	12.2-15.4
C5L/C5W	4.2-5.7	4.1-4.6	3.9-5.8
M5L/M5W	5.7-7.5	5.6-6.0	6.4-6.9
C5L/P5L	0.4-0.6	0.5-0.6	0.4-0.6
M5L/P5L	0.8-0.9	0.6-0.8	0.8-0.9

TABLE 2. Distinguishing characteristics of *Caridina zebra* Short, 1993, *C. confusa* sp. nov. and *C. spinula* sp. nov. CL, post-orbital carapace length.

	C. zebra	*C. confusa*	*C.spinula*
Distribution	mainly in rainforest-covered streams of the upper Tully, Herbert, Johnstone and Barron catchments	open grassland reaches of streams of the upper Johnstone and Barron catchments	rainforest-covered streams of Nisbet and Archer catchments in the McIlwraith Range, Cape York
Rostrum	to tip of 2nd segment of antennular peduncle, length 0.21-0.50 CL	to beyond tip of 2nd segment of antennular peduncle, length 0.43-0.76 CL	to tip of 1st segment of antennular peduncle, length 0.20-0.33 CL
Antennular peduncle length	0.58 ± 0.01 CL	0.69 ± 0.011 CL	0.58 ± 0.01 CL
Antennal peduncle length	0.40 ± 0.01 CL	0.52 ± 0.01 CL	0.44 ± 0.01 CL
Stylocerite	to tip of 1st antennular peduncle segment, length 0.30 ± 0.04CL	not to tip of 1st antennular peduncle segment, length 0.45 ± 0.05CL	not to tip of 1st antennular peduncle segment, length 0.32 ± 0.01CL
Scaphocerite length	0.61 ± 0.02 CL	0.94 ± 0.03 CL	0.62 ± 0.02 CL
Pterygostomian angle	bluntly angular	bluntly angular	bluntly angular to acute, spiniform
Length of 6th abdominal segment	0.48 ± 0.01CL	0.57 ± 0.01 CL	0.50 ± 0.11 CL
Length-depth ratio of 6th abdom. segment	1.26 ± 0.07	1.68 ± 0.03	1.65 ± 0.08
Protopod of uropod	elongate, spinose	short, acute	elongate, spinose
Telson	short, broad, 0.53 ± 0.02 CL, anterior telsonic width 0.44 ± 0.01 telsonic length, posterior telsonic width 0.19 ± 0.01 telsonic length	elongate, narrow, 0.75 ± 0.04 CL, anterior telsonic width 0.39 ± 0.01 telsonic length, posterior telsonic width 1.5 ± 0.01 telsonic length	short, broad, 0.54 ± 0.05 CL, anterior telsonic width 0.41 ± 0.01 telsonic length, posterior telsonic width 0.20 ± 0.01 telsonic length
Dorsal telsonic spination	to posterior two thirds of telson	confined to posterior half of telson	to posterior two thirds of telson
Telsonic margin	median spine may be present	median spine absent	median spine may be present
Diaeresis	16-21	10-16	16-22
Undev. egg (mm)	0.63-0.81 x 1.02-1.21	0.63-0.85 x 0.98-1.36	0.80-0.85 x 1.30-1.44
Dev. egg size (mm)	0.70-0.80 x 1.22-1.32	0.73-0.88 x 1.22-1.44	not available
Number eggs/female	38-57, mean 45	28-74, mean 51.5	17-18, mean 17.5

0.6 X as wide as carpus. Ischium length 0.41 X merus length. Epipod present.

Second pereiopod (Fig. 4j) reaching tip of 2nd segment of antennular peduncle, more slender and longer than 1st pereiopod. Chela length 2.4-2.9 X width; movable finger length 3.2-4.5 X width, 1.6 X as long as palm; finger tips without hooks, setal brushes well-developed. Carpus subconical, length 5.8-6.1 X width, 1.4-2.0 X chela length, 1.1 X merus length. Ischium length 0.48 X merus length. Epipod present.

Third pereiopod (Fig. 4k, l) over-reaching antennular peduncle tip by about 0.33 distal propodus. Dactylus sexually dimorphic in adults, length c. 2.6 X width, c. 0.25 X propodus length, ending in prominent claw-like hamate seta surrounded by simple setae, behind which posterior margin bears 4-5 shorter spiniform hamate setae, these being more robust and upright in adult ♂ ♂. Propodus length 10.5-13.0 X width, posterior margin and lateral surface bearing rows of small spiniform hamate setae. Carpus length 0.6-0.8 X propodus length, distal projection feebly developed, posterior and lateral surfaces with 1 large and up to 5 small hamate setae, more spiniform setation in adult ♂ ♂. Merus 1.6-1.9 X length of carpus, with 2-4 strong, movable spiniform hamate setae along posterior margin. Ischium 0.3 X length of merus. Epipod present.

Fourth pereiopod reaching tip of 2nd segment to tip of 3rd segment of antennular peduncle, morphologically similar to 3rd pereiopod.

Fifth pereiopod (Fig. 4m, n) reaching tip of 2nd segment to tip of 3rd segment of antennular peduncle. Dactylus unguiculate, compressed, length c. 4.0 X width, ending in claw-like apical hamate seta, bearing comb-like row of 45-55 hamate setae gradually increasing in length distally on posterior margin. Propodus length 12-15 X width, 3.3 X dactylus length, bearing rows of 10-15 short hamate setae on posterior margin. Carpus length 0.4-0.6 X propodus length, bearing 2-7 short hamate setae, distal projection well-developed. Merus shorter (0.8-0.9 X) but broader (1.5 X) than propodus, bearing 2-4 large spiniform hamate setae. Ischium c. 0.3 X length of merus, with simple setae. Epipod absent.

Abdomen (1c) well-developed, rotund, glabrous, c. 3 X CL; 6th abdominal segment elongate, c. 0.5 X CL, length-depth ratio c.1.8; protopod of uropod acute, aspinose; telson (Fig. 4o) broad, length c. 0.5 X CL, dorsal spination (3-5 pairs) confined to posterior 0.66 of telson; posterior telsonic margin rounded, 4-5 pairs of spine-like setae, decreasing in size anteriorly, median spine may be present; diaeresis on telsonic exopod 16-22.

First ♂ pleopodal endopod (Fig. 4p) with well-developed appendix interna arising sub-distally.

Appendix interna of 2nd ♂ pleopodal endopod (Fig. 4q) reaching beyond middle of appendix masculina, with many retinaculae distally. Appendix masculina subcylindrical, long hamate setae distally and on inner lateral margin.

Live colour, translucent brown.

ETYMOLOGY. The specific name refers to the distinctive, spiniform pterygostomian angle which may be present in some specimens. No other Australian *Caridina* species exhibits this spiniform pterygostomian angle.

REMARKS. Although *C. spinula* sp. nov. looks very much like *C. zebra*, there are distinct morphological differences (Tables 1 and 2). The spiniform pterygostomian angle in specimens from Leo Creek is also very distinctive. This species is currently known only from the McIlwraith Range in the Cape York Peninsula and, despite extensive sampling, has not been found on the Atherton Tablelands around the Lamb-Francis-Cardwell Ranges (where *C. zebra* and *C. confusa* sp. nov. are found). The only other likely area of its occurrence between the Atherton Tableland and the McIlwraith Range that we have not sampled is the Cape Tribulation/Daintree area. However, none were found here during other sampling trips (J. Short and B. Herbert, pers. comm.). The Leo Creek tributary from where *Caridina spinula* sp. nov. was collected consists of a series of riffles and pools no more than 3m long, 1m wide and 0.3m deep, flowing over a substrate of bedrock with some sand and gravel. Discharge at time of sampling was approximately 1 Ls^{-1}. Vegetation in the area is tropical mesophyll rainforest with a closed canopy at only 6-8m and some emergent vegetation. The low canopy suggests that this area may have recently been disturbed (David Hanger, pers. comm.). Density of the shrimp was low (1-$2m^{-2}$). Other animals recorded from the collection site include the prawn *Macrobrachium tolmerum* (Decapoda: Palaemonidae) and the frogs *Litoria genimaculata*, *L. longirostrus* (Anura: Hylidae), *Sphenophryne gracilipes* (Anura: Microhylidae) and *Rana daemeli* (Anura: Ranidae).

DISCUSSION

The *Caridina typus* species-group, characterised by its short, dorsally unarmed rostrum, can be identified using the key of Choy and Horwitz (1995) (to couplet 6, p. 52). The four species can then be identified using the following key.

1. Rostrum long, extending beyond tip of second segment of antennular peduncle, 0.4-0.8 times carapace length; stylocerite long, 0.4-0.5 times carapace length; sixth abdominal segment long, 0.55-0.59 times carapace length . . . . . *Caridina confusa* sp. nov.

   Rostrum short, not reaching tip of second segment of antennular peduncle, 0.2-0.5 times carapace length; stylocerite and sixth abdominal segment short, <0.4 and <0.5 times carapace length respectively 2

2. Rostrum somewhat laterally flattened, with 1-5 teeth on ventral margin; posterior telson margin angular, median plumose setae on posterior telson margin with sclerotinous plug; eggs small, <0.6mm long . . . . . *C. typus*

   Rostrum somewhat dorsoventrally flattened, ventral teeth usually absent although one may be present; posterior telson margin rounded, median plumose setae without sclerotinous plug; eggs large, >0.8mm long 3

3. Rostrum short, not extending beyond tip of first segment of antennular peduncle; length to depth ratio of sixth abdominal segment >1.4, number of eggs carried by female <25 . . *C. spinula* sp. nov.

   Rostrum relatively long, usually extending beyond tip of first segment of antennular peduncle, length to depth ratio of sixth abdominal segment <1.4, number of eggs carried by female >30 . . . . . *C. zebra*

Caridina zebra Short, 1993, *C. confusa* sp. nov. and *C. spinula* sp. nov. may also be separated on the basis of distinguishing characters given in Tables 1 and 2. It is emphasised that individual characters may be highly variable and so a combination of characters should be used to confirm the identity of keyed out specimens. The relationship between carapace length, rostrum, and the sixth abdominal segment lengths are linear for all three species (Fig. 5). The slopes and intercepts of the regression lines are significantly different for *C. confusa* when compared to the other two species ($P>0.05$). All three species tend to be allopatric. It is only in and near the short rainforest reaches of Gwynne and Thiaki Creeks that *C. zebra* and *C. confusa* are sympatric. Although *C. zebra* has been collected from some open, para grass infested and anthropogenically disturbed reaches of streams (e.g., Raspberry, Ithaca and Prior's Creeks) it does not appear to be very tolerant of these conditions. It seems to prefer the rainforest reaches of stream. *C. zebra* is a rotund animal, more commonly found on sandy, silty and/or leaf litter beds of riparian-covered rainforest streams and is particularly abundant in the more elevated, cooler areas (c. 800-950m), where fish predators and crustacean competitors are ab-

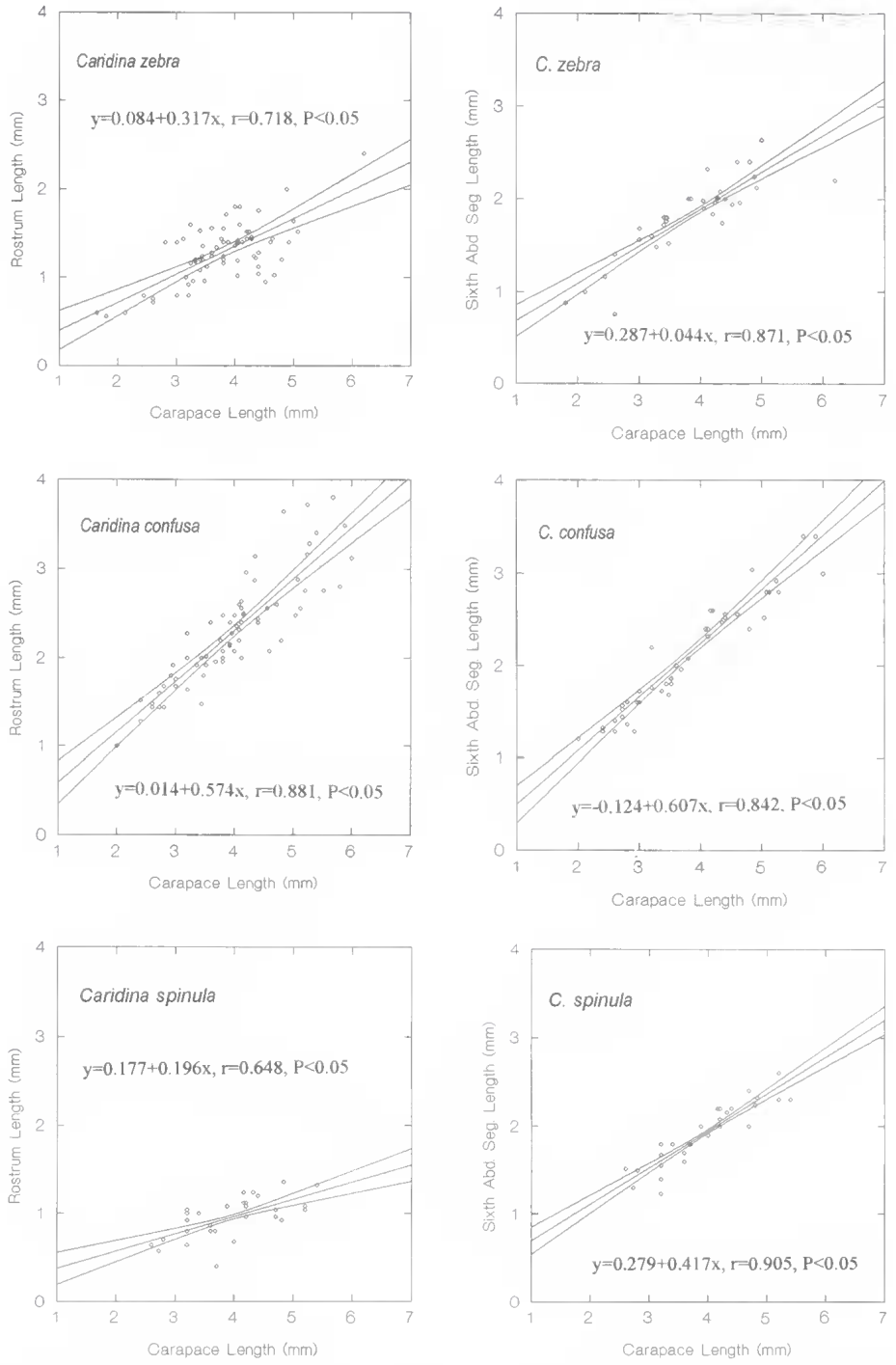

FIG. 5. Correlation between carapace length, rostrum length and sixth abdominal segment length of *Caridina zebra*, *C. confusa* sp. nov. and *C. spinula* sp. nov. All regressions are significant (P<0.05). The slopes and intercepts of the regression lines of the appropriate variables between *C. confusa* and *C. zebra* and between *C. confusa* and *C. spinula* are significantly different (ANOCOVA, P>0.05).

sent. *C. confusa* sp. nov. is a more elongate, slender animal more commonly found amongst the bank vegetation (particularly para grass) of streams flowing through open grassland areas of the Atherton Tableland.

It is likely that both the species were present in these previously rainforested areas. The modified environment may be favouring *C. confusa*, hence its predominance in these areas.

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